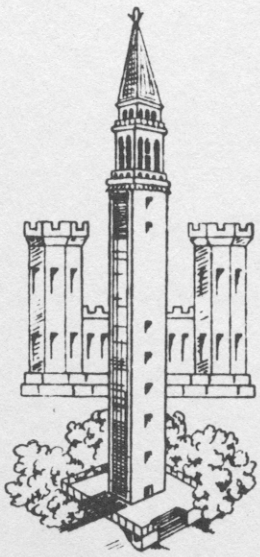
MEYER-PETER FORMULA FOR BED-LOAD TRANSPORT AND EINSTEIN BED-LOAD FUNCTION

By

Ning Chien



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CORPS OF ENGINEERS SEDIMENT STUDIES PROGRAM

FOR MISSOURI RIVER BASIN

MISSOURI RIVER DIVISION

FORT PECK DISTRICT — OMAHA DISTRICT

GARRISON DISTRICT — KANSAS CITY DISTRICT

The Corps of Engineers Missouri River Basin sediment studies program was established for the development of practical sediment engineering for rational evaluation, regulation, and utilization of fluvial sediment phenomena. It was implemented as a comprehensive, basin-wide program for coordination of studies of sediment problems in the overall basin program for flood control and allied purposes as well as for continuity and perspective in the planning and design of individual projects. The program includes both investigations for the development of sediment transport theory and observations of existent and occurring phenomena for the purpose of developing the applications of theory to practical problems, developing empirical relationships, and providing aids to judgment.

The program has been conducted during the tenures of and supported by the following Division Engineers:

Lieutenant General Lewis A. Pick
Major General Samuel Sturgis
Brigadier General Don G. Shingler
Brigadier General W. E. Potter

Mr. F. B. Slichter was Chief of the Engineering Division from the inception of the program until April 1949. Mr. W. E. Johnson has been Chief of the Engineering Division since that time. The program was formulated and organized by Mr. R. J. Pafford, Jr., Chief, Planning and Reports Branch. Planning and execution is under the immediate direction of D. C. Bondurant with technical advice and assistance provided by an Advisory Board consisting of:

Mr. G. A. Hathaway
Dr. H. A. Einstein
Mr. E. W. Lane
Mr. T. H. Means
Dr. L. G. Straub
Dr. V. A. Vanoni

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INTRODUCTION

The movement of sediment along the bed of alluvial streams has long been a subject of interest to hydraulic engineers. As early as in 1879 DuBoys[1] published a formula for bed-load transport in which he first introduced the idea of critical tractive force for the initiation of sediment movement. In 1914 Gilbert[2] pioneered in making sediment transportation experiments in flumes and greatly advanced the research in this field. Since then, numerous laboratory studies of sediment transportation have been conducted throughout the United States and the continent of Europe, from which a large number of sediment transportation formulas were developed. In the course of the studies, it was found that the difficulty of analysis did not lie in the establishment of equilibrium conditions for the sediment movement but rather in the proper description of the flow. For instance, in laboratory studies where the flow is generally confined, the effect of the side-walls of the flume on the resistance of flow must be considered. In addition, the frictional resistance on the sediment bed developed in two distinctly different ways; that is, (a) along the sediment grains of the bed as a boundary with the representative diameter equal to K_s, and, (b) by the separation of the flow from the bed surface at characteristic points of the ripples and bars which results in a pressure difference between the front and rear sides of each bar. Part of the flow resistance is thus transmitted to the bed by this shape resistance. The distinction

between the two is important, since it is only the turbulence generated by direct transmission of shear to the sediment grains at the bed which is responsible for the bed-load movement. The turbulence, generated by the transmission of energy corresponding to the shape resistance at the interface between wake and free stream flow, originates at a considerable distance away from the grains and has little to do with the bed-load motion of the particle[3].

In the light of the existence of different frictional mechanisms in an alluvial channel flow, most of the bed-load formulas have failed to differentiate between the effects of the individual mechanisms on the sediment motion. The applicability of these formulas are, therefore, limited. There are two exceptions. One is the Meyer-Peter formula developed at the Laboratory for Hydraulic Research and Soil Mechanics at the Federal Institute of Technology, Zurich, Switzerland[4]. This formula has been used quite extensively in Europe. The other formula is the bed-load function proposed by Einstein[3] which has been adopted by American engineers. These two studies are based on a similar description of the flow, and the discussion to follow is a comparison between these two relationships.

Hydraulics of an Alluvial Channel

It has been found that in flow systems in which a rough surface is arranged in an irregular manner, such that the irregularities are at least 5-10 times larger than the roughness, i.e., where two or more systems of roughness of different order of magnitude are superimposed, the contributions of the individual systems can be calculated independently and added